Hedge Fund Index Replication - A Numerical Approach using Futures

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I.   Introduction

The goal of this paper is to propose a futures-based replicator for the Credit Suisse Hedge Fund Index (HFI). Some of the benefits of this replication are:

1) It is not skill based.
2) It is cheap.
3) It is tradable and liquid therefore not vulnerable to stale pricing and smoothing of returns such as is apparent in the hedge fund indexes.
4) It has no lock ups and provides intraday trading, subscription and redemption opportunity.
5) It is fully transparent.
6) The tail risk component is visible and measurable in comparison to being opaque in typical hedge fund styles.
7) Capital efficiency is highly superior as futures can be traded on margin using less than 5% of face value of HFI being replicated.
8) It can reasonably be replicated in a managed account format as it is not trading intensive.
9) It provides a framework for timing specific factors on a momentum basis.

The replication is numerical and top-down in nature. It does not try to clone qualitatively the exact strategies or portfolios bottom-up within the HFI. The period we utilized for the replication is from August 2004[1] to August 2014. Themes within the hedge fund industry have rotated over the years. For example, until the mid-90s, hedge funds had much more exposure to macro style trading. In the late 90's the technology sector had a large role in hedge fund returns. From 2003 to 2008, commodities and emerging markets played a major role. Since 2009, long equity, activist style investing and credit are playing a major role and macro trading is less relevant. It is rare for specific funds to continue outperforming over more than one of these theme driven regimes.

We want to emphasize that numerical correlation does not imply causation. Pure mathematical, top-down optimizations rarely achieve their expected results outside the optimization window. Future tracking error on our replicators could therefore be larger than anticipated. To minimize this risk, we are using a relatively low number of separate factors (four) and they are commonsensical. We therefore have some degree of confidence in the optimization. The benefits of the replication are significant when the weaknesses of numerical optimizations are adequately taken into account[2]. We are of the mindset that shorting volatility directly, and therefore being conscious of tail risk exposure, provides similar returns and risk adjusted returns as liquid hedge fund strategies. Risk arbitrage, equity market neutral, and value investing are such liquid strategies that could be replicated using a non-linear risk-adjusted model. As explored in our second research piece[3], we are using drawdown as a measure of risk rather than standard deviation due to the non-linear risk of hedge funds. As specific individual risk factors driving hedge fund returns are brought to light, it is only a question of time before investable hedge fund indexes replicate, outperform and improve terms on the specific hedge funds they clone. What today is broadly considered skill in the hedge fund industry will one day be related to replicable risk factors. With tail risk and liquidity accounted for, skill-

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[1] VIX futures only became available in March 2004.
[2] Quest Partners has successfully run a replicator of the CTA industry. Since inception in August 2011, this replicator has outperformed the actual indexes by +3% a year and with 80% correlation.
[3] AlphaQuest CTA Research Series #2 Know Your Skew - Using Hedge Fund Return Volatility as a Predictor of Maximum Loss By Nigol Koulajian and Paul Czkwianianc, Quest Partners LLC *June 2011*

free macro factors should succeed at replicating the crowded hedge fund industry accurately. In other words, superior security selection does not need to be the driving factor behind the Alpha of the HFI to the SP500.

II.   The Replication – Model 1

We use a four factor model to replicate the HFI. These factors are:

1) The SP500 future (SP500). This is to account for US stock market exposure. The returns of the SP500 future contract account for dividend capture.
2) The MSCI Emerging Market index future (MXEF)[4] to account for global stock market exposure.
3) The CBOE SP500 Volatility index future (S_VIX). This is an important factor which accounts for the tail risk exposure of hedge funds. We are short this factor.
4) A trend following model on a futures / FX portfolio. The model we use here is a 10 day to 200 day simple moving average crossover strategy trading long/flat (MA10x200_L). The portfolio and position sizing is as per our first research piece[5].

The weights of the four factors are chosen to be kept constant over time. We do not use a linear regression or least square analysis in the optimization process.

The first model (Model 1) has the following exposures: +20% exposure to the SP500, -1% exposure to the VIX future (+1% in S_VIX), +13.7% exposure to the MXEF and +11.6% exposure to the MA10x200_L.
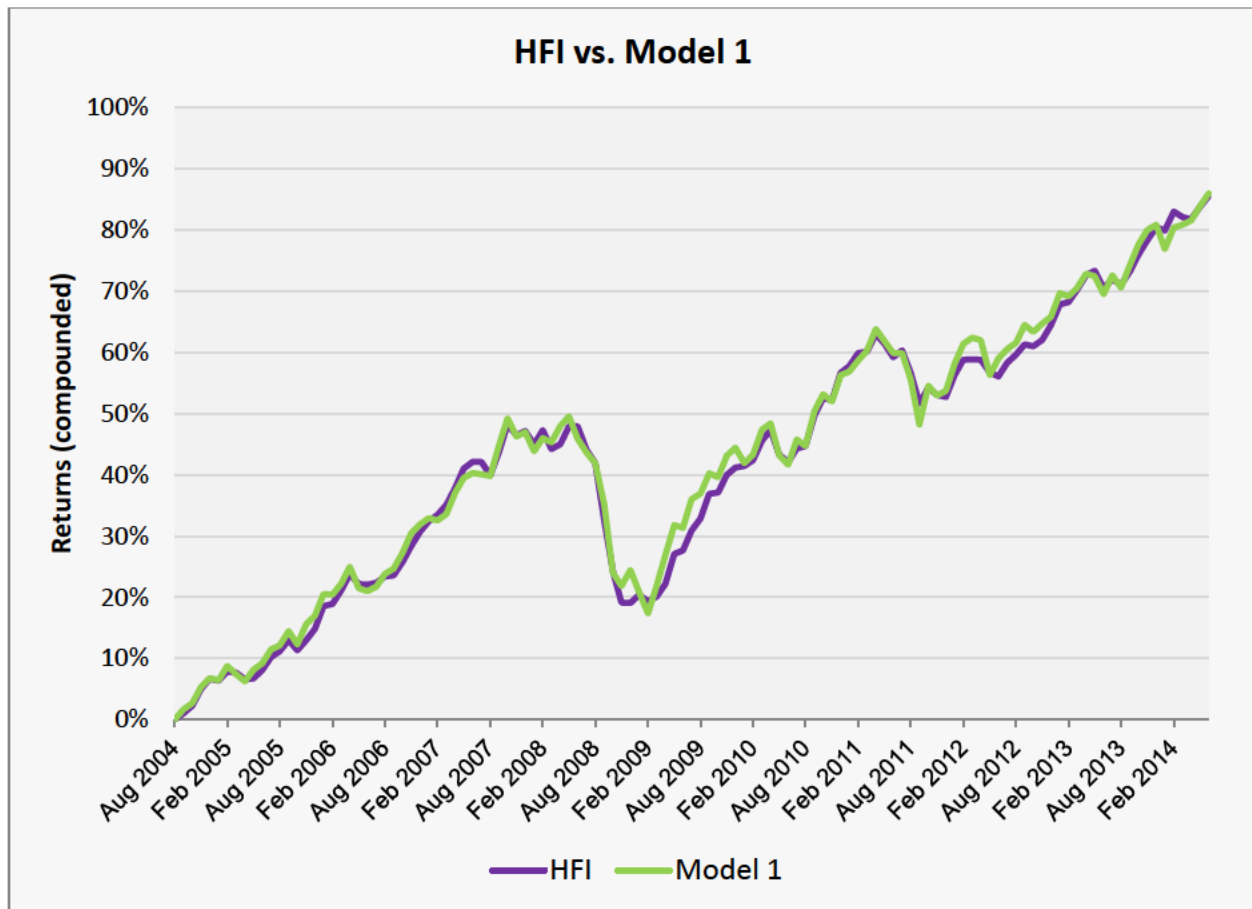
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[4] Prior to 2009, the MXEF total return unfunded index was utilized.
[5] AlphaQuest CTA Research Series #1 Black Box Trend Following – Lifting the Veil by Nigol Koulajian and Paul Czkwianianc, Quest Partners LLC *September 2010*

III.   Model 1 NAV Graph

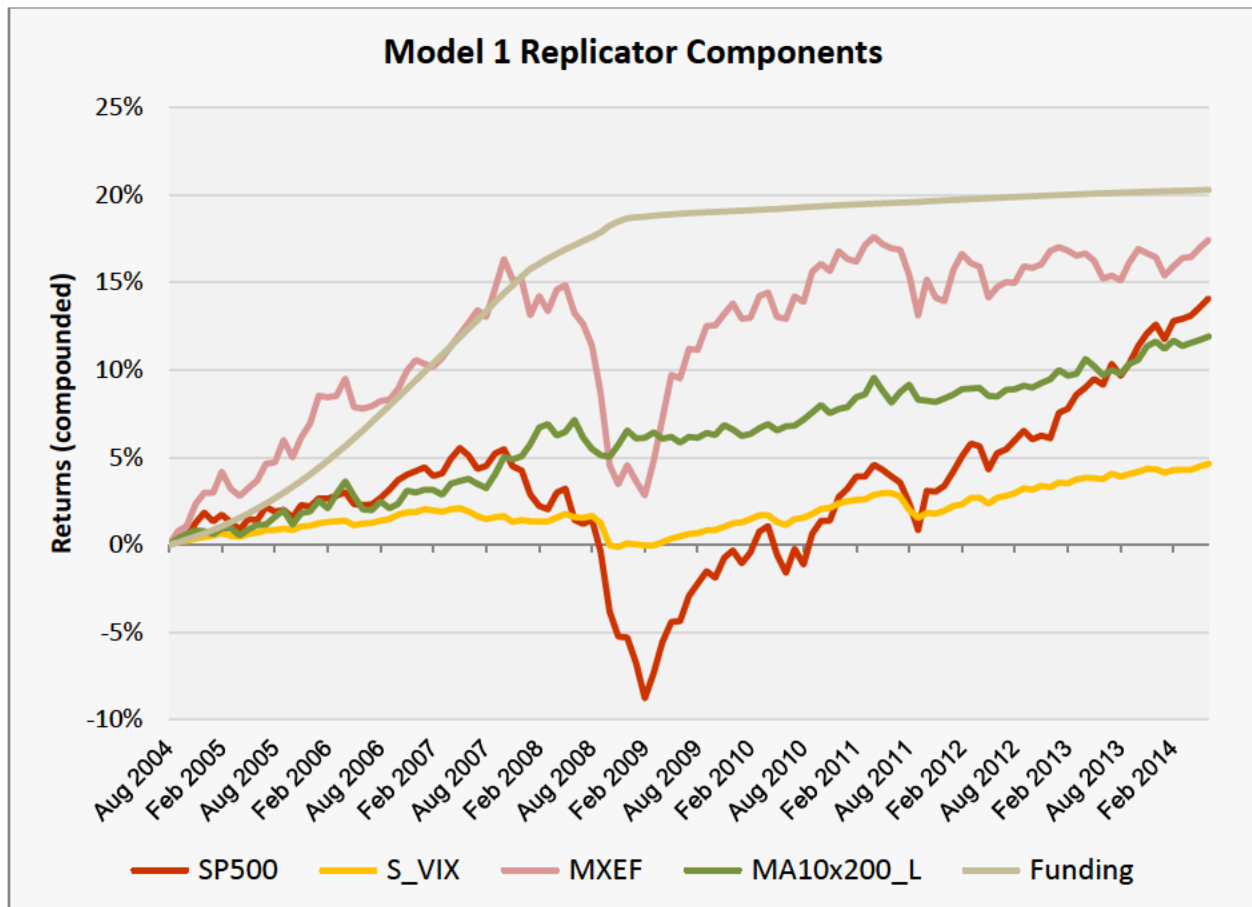**HFI vs. Model 1**

Model 1 tracks the HFI very closely but also appears to be slightly more volatile.

IV. Model 1 Individual Component NAV Graphs

Model 1 Replicator Components

Legend: SP500, S_VIX, MXEF, MA10x200_L, Funding

Funding, emerging markets and US equities are all major components. Macro style trading such as MA10x200_L is significant as well.

V.   Model 1 Return Statistics

All returns are unfunded

	HFI	**SP500**	**S_VIX**	**MXEF**	**MA10x200_L**	**Model 1**
Weights (% of HFI face value)		**20.0%**	**1.0%**	**13.7%**	**11.6%**	
Total Return (compounded)	54.3%	14.1%	4.6%	17.4%	11.9%	54.6%
Trading Periods (months)	118	118	118	118	118	118
Annualized Return (compounded)	4.5%	1.4%	0.5%	1.6%	1.2%	4.5%
Annualized Volatility	6.0%	3.0%	0.7%	3.3%	1.4%	7.1%
Worst Drawdown	-22.6%	-13.6%	-2.2%	-11.6%	-2.0%	-24.3%
Skew	-1.42	-0.82	-2.63	-0.69	-0.27	-1.00
Sharpe Ratio	0.76	0.45	0.63	0.50	0.80	0.64
Ann Return / Worst Drawdown	0.20	0.10	0.21	0.14	0.59	0.19
Beta to SP500	**0.30**	0.20	0.04	0.17	0.02	**0.43**
Correlation to SP500	75.3%	100.0%	78.6%	79.0%	24.5%	91.3%
Annual Alpha to SP500	2.7%	0.0%	0.2%	0.6%	1.0%	1.9%
Information Ratio to SP500	0.70	0.00	0.51	0.31	0.73	0.67
Beta to HFI	1.00	0.38	0.09	0.45	0.11	1.03
Correlation to HFI	100.0%	75.3%	70.5%	82.4%	47.4%	**86.2%**
Annual Alpha to HFI	0.0%	-0.4%	0.1%	-0.4%	0.6%	-0.1%
Information Ratio to HFI	0.00	-0.18	0.13	-0.21	0.50	-0.03
Correlation to BTOP50	28.5%	-0.9%	-2.4%	11.4%	64.3%	17.6%
Autocorrelation (lag1)	**37.2%**	19.3%	22.8%	16.6%	-6.4%	**13.7%**

Model 1 achieves a highly significant +86.2% correlation of monthly returns to the HFI. Returns, volatility and drawdown for the HFI versus Model 1 are statistically similar.

A statistic that stands out is the Beta to the SP500 of Model 1. Model 1's Beta to the SP500 is +43% vs. HFI Beta to the SP500 of +30%. Also, the month to month return autocorrelation of the HFI returns is +37.2% which is significantly higher than the +13.7% autocorrelation of Model 1. Considering the close fit of all the other parameters, we suspect that this difference is due to stale pricing in the HFI. Stale pricing is not present in Model 1. In order to introduce stale pricing in the replication, we add a fifth factor which is a lagged SP500 return (SP500_lag). SP500_lag is set to be the sum of the SP500 return from two months ago x 1/3 plus the SP500 from last month x 2/3. The sum of the returns of the SP500 and SP500_lag are similar over the period by definition. We suspect that the HFI does not reflect the actual returns of the underlying securities held at that point in time due to:

1) the illiquid nature of the securities held,
2) delays in monthly reporting by some managers,
3) quarterly rather than monthly NAV reporting by some managers,

4) the smoothing of returns by hedge fund managers in order to lower perceived volatility and market exposure.

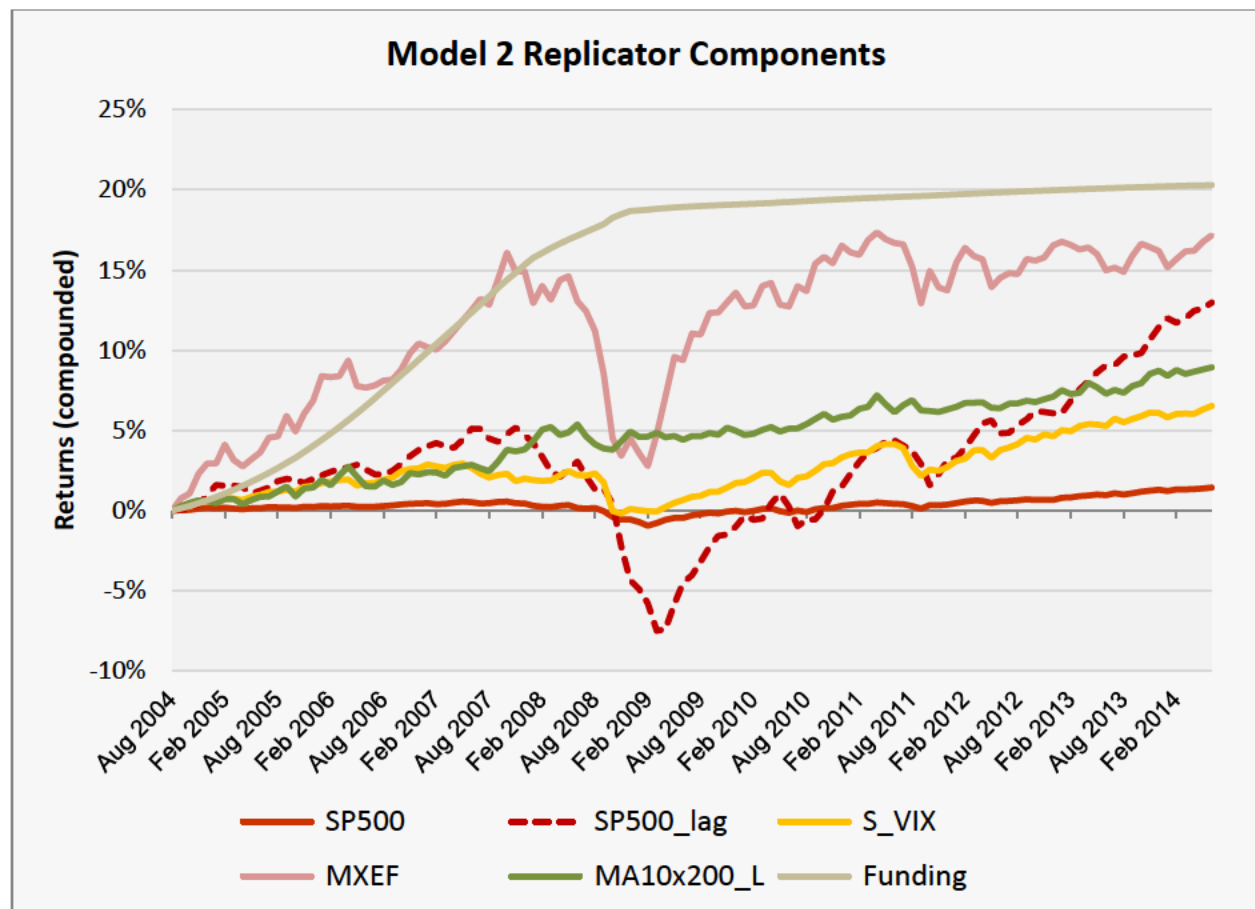We will now re-attempt our replication after adding SP500_lag as a factor (Model 2).

VI.   Model 2 NAV Graph
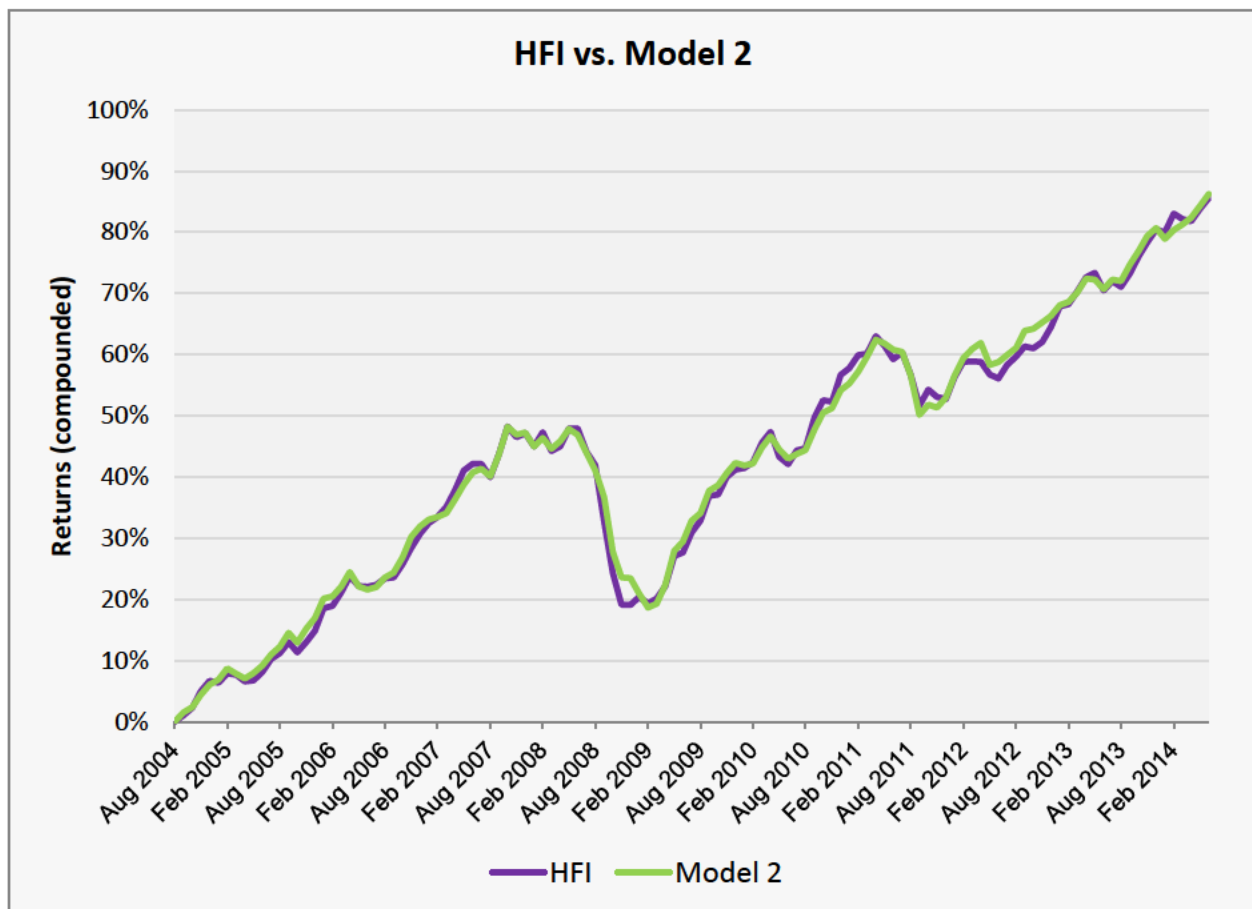
Model 2 returns match the HFI exceptionally well and even better than Model 1.

VII. Model 2 Individual Component NAV Graphs

Model 2 Replicator Components

Here again, funding, emerging market equities and macro trading are important factors in the replication. The lagged SP500 is a much larger component than the SP500 itself! A large portion of HFI's Alpha to the SP500 is due to stale pricing of securities or in other words, artificial smoothing of returns. We suspect that this fact would be quite surprising to most hedge fund investors although it has been well documented in the hedge fund literature.

VIII. Model 2 Return Statistics

All returns are unfunded

	HFI	SP500	SP500_lag	S_VIX	MXEF	MA10x200_L	Model 2
Weights (% of HFI face value)		2.1%	22.8%	1.4%	13.5%	8.8%	
Total Return (compounded)	54.3%	1.4%	13.0%	6.5%	17.2%	8.9%	54.8%
Trading Periods (months)	118	118	118	118	118	118	118
Annualized Return (compounded)	4.5%	0.1%	1.2%	0.6%	1.6%	0.9%	4.5%
Annualized Volatility	6.0%	0.3%	2.2%	1.0%	3.2%	1.1%	5.4%
Worst Drawdown	-22.6%	-1.5%	-12.0%	-3.0%	-11.5%	-1.5%	-22.9%
Skew	-1.42	-0.82	-1.31	-2.63	-0.69	-0.27	-1.30
Sharpe Ratio	0.76	0.46	0.56	0.63	0.50	0.80	0.84
Ann Return / Worst Drawdown	0.20	0.10	0.10	0.21	0.14	0.59	0.20
Beta to SP500	0.30	0.02	0.02	0.05	0.17	0.02	0.29
Correlation to SP500	75.3%	100.0%	15.9%	78.6%	79.0%	24.5%	79.2%
Annual Alpha to SP500	2.7%	0.0%	1.1%	0.3%	0.6%	0.8%	2.8%
Information Ratio to SP500	0.70	0.00	0.50	0.51	0.31	0.73	0.86
Beta to HFI	1.00	0.04	0.13	0.12	0.45	0.09	0.83
Correlation to HFI	100.0%	75.3%	35.6%	70.5%	82.4%	47.4%	90.9%
Annual Alpha to HFI	0.0%	0.0%	0.6%	0.1%	-0.4%	0.5%	0.8%
Information Ratio to HFI	0.00	-0.16	0.31	0.13	-0.21	0.50	0.36
Correlation to BTOP50	28.5%	-0.9%	-4.4%	-2.4%	11.4%	64.3%	17.4%
Autocorrelation (lag1)	37.2%	19.3%	56.4%	22.8%	16.6%	-6.4%	44.8%

The correlation of Model 2 to the HFI is +90.9% which is very significant. In model 2, the short VIX exposure has gone up slightly from +1% to +1.4%, MXEF exposure remains similar at around +13.5% and MA10x200_L exposure comes down slightly from +11.6% to +8.8%.

Model 2's autocorrelation at +44.8% is also much closer to the +37.2% autocorrelation of HFI. We see that the SP500 weight is down from +20% in our previous model to +2.1% only. This drop in SP500 exposure is countered by a major exposure increase of +22.8% to the lagged SP500. Stale pricing seems to be a major reason why the HFI has a relatively low Beta of 30% to the SP500. +1.1% out of +2.7% of the HFI's Alpha to the SP500 is coming from stale or lagged pricing. So 41% of HFI's Alpha to the SP500 is due to the fact that SP500 related returns are lagged or smoothed out over time. Also, without stale pricing, the models indicate that HFI's Beta to the SP500 would be almost 43% higher at +43% instead of +30%. Stale pricing is a substantial risk factor which needs to be taken into account when looking at hedge fund returns. The entire Alpha of the HFI to the SP500 is accounted for by skill-less, well-known and untimed factors as in Model 2. If superior security selection is a source of Alpha for the HFI, we do not see any evidence of it!

IX.   Model 3 - HFI Replication Using Individual Factor Long / Flat Timing NAV Graph

A major benefit of only using liquid factors in the replication process of the HFI is that these factors are tradable on a monthly, daily or even intra-day basis.

We will now apply a simple market timing model to the four components of Model 1. We will stay away from utilizing the important SP500_lag factor as its benefits are deceptive in nature. Although the four factors of Model 1 are highly liquid and tradable daily, we use a relatively slow 1 month to 5 months moving average model to trade the factors long / flat in Model 3. When the factor is above its own 5 month moving average, we will be long that factor and flat that factor otherwise[6]. More complex trading methodologies are available but we will refrain from using them at this stage in order not to rely on skill in any way.
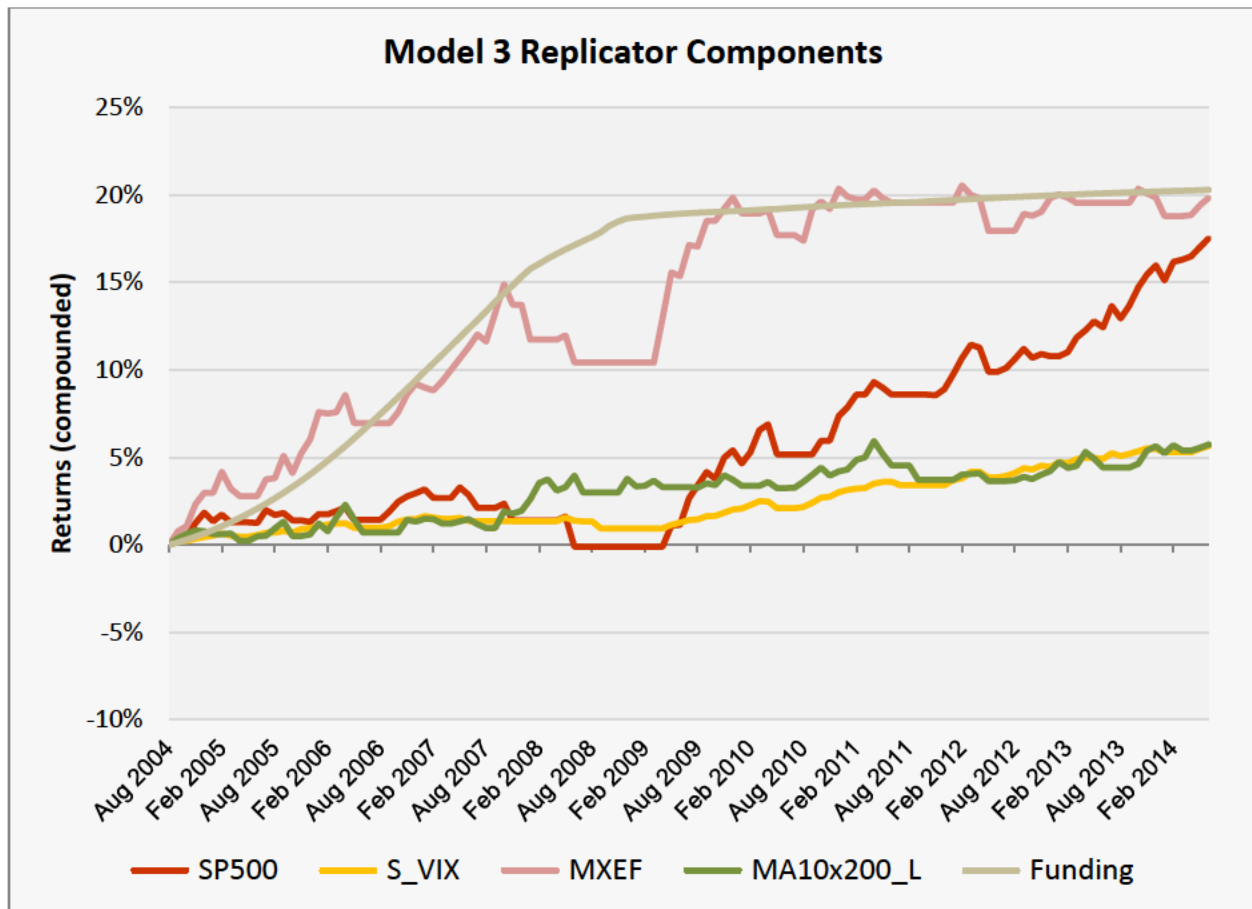

HFI vs. Model 1 and Model 3
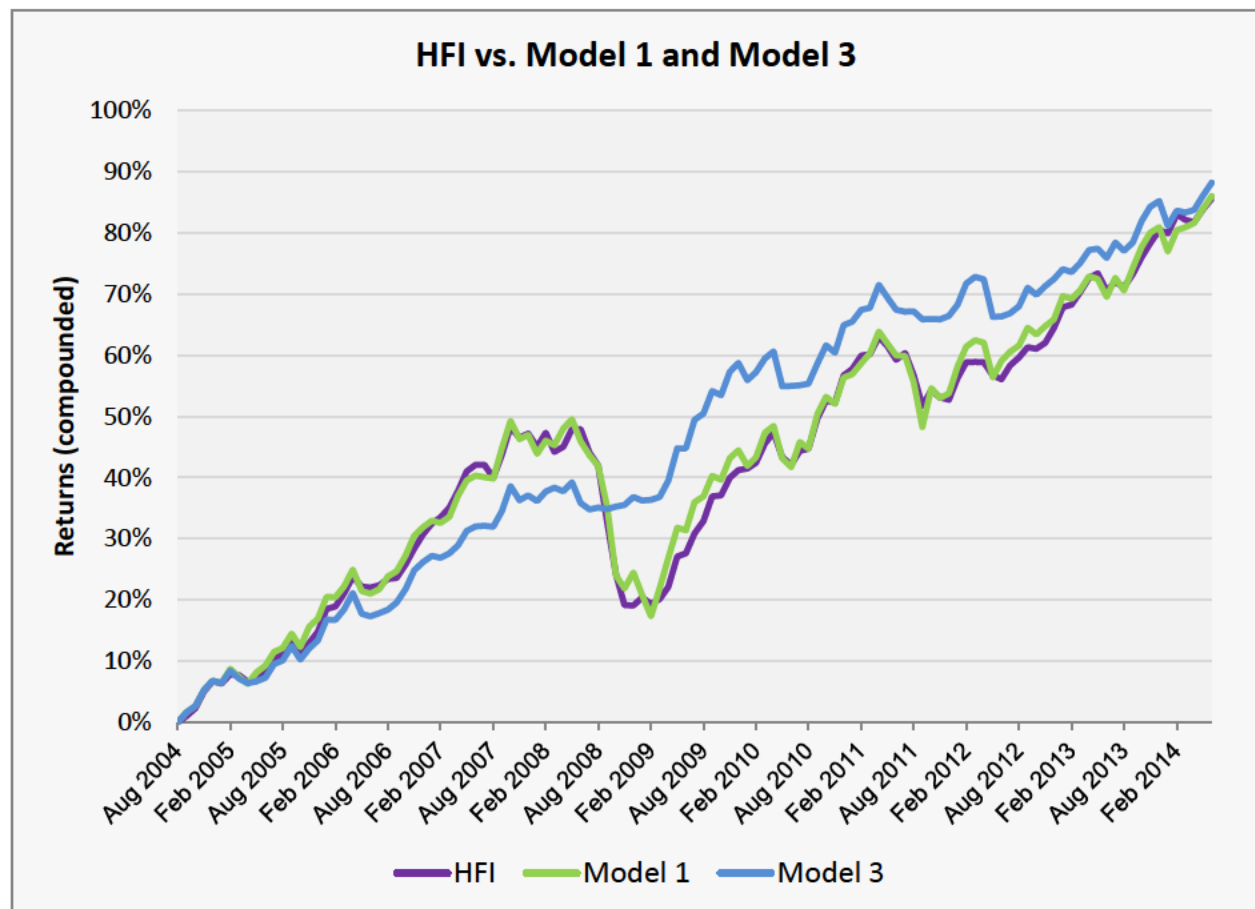
Timing the individual four factors that compose Model 1 is very beneficial on a risk adjusted return or risk basis. Returns improve only slightly.

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[6] This is a similar time frame to the model that we used in our first research piece on trend following replication.

X.   Model 3 – Individual Factor NAV Graphs

The timing methodology helps improve the risk adjusted returns and risk characteristics of all four factors individually. The upside potential of the factors is not affected by the timing model.

As a side note, factor timing is most ideal neither on individual securities nor at a macro level such as with these four high level factors. Instead, market timing's value is maximized at an intermediate level of risk aggregation between systemic and idiosyncratic risk. This is the case due to more internal diversification and also, a better quality of trends at the intermediate factor level. Even higher Alpha per unit of risk can be extracted if one were to apply timing at this intermediate level.

XI. Model 3 Return Statistics

All returns are unfunded

	HFI	SP500 Timing	S_VIX Timing	MXEF Timing	MA10x200_L Timing	Model 3
Weights (% of HFI face value)		20.0%	1.0%	13.7%	11.6%	
Total Return (compounded)	54.3%	17.5%	5.6%	19.9%	5.7%	56.5%
Trading Periods (Months)	118	118	118	118	118	118
Annualized Return (compounded)	4.5%	1.7%	0.6%	1.9%	0.6%	4.7%
Annualized Volatility	6.0%	1.8%	0.5%	2.3%	1.3%	4.6%
Worst Drawdown	-22.6%	-3.3%	-0.7%	-3.9%	-2.2%	-5.6%
Skew	-1.42	-0.43	-0.51	0.31	-0.05	-0.45
Sharpe Ratio	0.76	0.91	1.23	0.79	0.44	1.02
Ann Return / Worst Drawdown	0.20	0.50	0.82	0.48	0.26	0.83
Beta to SP500	0.30	0.08	0.02	0.08	0.02	0.19
Correlation to SP500	75.3%	61.7%	56.1%	50.8%	21.4%	62.5%
Annual Alpha to SP500	2.7%	1.2%	0.5%	1.4%	0.5%	3.5%
Information Ratio to SP500	0.70	0.84	1.22	0.68	0.36	0.99
Beta to HFI	1.00	0.16	0.04	0.22	0.10	0.52
Correlation to HFI	100.0%	51.8%	55.9%	56.5%	44.1%	67.9%
Annual Alpha to HFI	0.0%	0.9%	0.4%	0.9%	0.1%	2.3%
Information Ratio to HFI	0.00	0.60	0.98	0.44	0.11	0.69
Correlation to BTOP50	28.5%	28.4%	19.5%	27.5%	57.1%	43.7%
Autocorrelation (lag1)	37.2%	2.9%	8.5%	4.2%	-5.4%	-1.5%

The factor timing model on the HFI replicator has similar returns as the HFI. Volatility is reduced by 23% from 6% to 4.6%. Please note that HFI's monthly return volatility is somehow fictitiously low due to stale pricing as opposed to the volatility of Model 3 returns which relies on realistic prices of liquid contracts. Based on the non-stale pricing based replication of Model 1, HFI return volatility would be 7.1% instead of the 6% of the HFI or 18% higher. When stale pricing is taken into account, then the timing model reduces the volatility of the HFI from 7.1% to 4.6% or 45%.

Using Model 3, the worst drawdown is reduced by 75% vs. the HFI. Sharpe ratio is improved by 34% and return / drawdown is improved by over 300%. Beta to the SP is reduced to +19% from +43% for the untimed replicator and +30% for the stale priced HFI.

Factor timing seems to be highly beneficial when replicating the HFI. These benefits are substantial and would most probably counter the possible loss in returns and risk adjusted returns due to the optimization used in the replication process.

XII. Conclusion

Our numerical replication of the HFI using liquid factors is significant and stable over the test period. It does not rely on least square analysis. Its correlation to the HFI is close to +90%.

Our replications show that superior security selection has little or no impact on HFI's Alpha to the SP500. **In particular, HFI's Alpha to the SP500 is explained:**

1) **41% by stale pricing,**
2) **11% by replicable tail risk (unaccounted for by linear Beta models),**
3) **22% by exposure to non-US stock indexes,**
4) **30% by skill-less macro style trading using classical trend following models.**

Replication provides significant improvement vs. the HFI from the following perspectives:

1) It is not skill based.
2) It is cheap.
3) It is tradable and liquid therefore not vulnerable to stale pricing and smoothing of returns.
4) It has no lock ups and provides intraday trading, subscription and redemption opportunity.
5) It is fully transparent.
6) The tail risk component is visible and measurable in comparison to being opaque in typical hedge fund styles.
7) Capital efficiency is highly superior as futures can be traded on margin.
8) It can reasonably be replicated in a managed account format as it is not trading intensive.
9) It provides a framework for timing specific factors on a momentum basis.

The replication highlighted an additional risk that hedge fund investors might not be fully accounting for: stale pricing and return smoothing in the hedge fund indexes. In our past research pieces, we have illustrated that in the recent decade, markets have been negatively skewed and have provided low volatility based returns which underestimate their drawdown potential. We have also shown that investors are mispricing risk by using linear risk models while their hedge fund positions, such as spreads, have non-linear risk. We have also argued that hedge fund managers are increasing their equity exposure after equity corrections in order to benefit from the mean reverting character of financial markets in the US in particular. With stale pricing as an additional source of hidden market risk and erroneously assigned Alpha, investors must be aware that in the hedge fund industry, what you see is not necessarily what you get.

There is the risk of underperformance associated with top-down replication. Factor timing provides substantial improvements in risk and risk adjusted returns versus the HFI. These improvements offset the risk of underperformance associated with top-down replication. The hedge fund industry, like the mutual fund industry, seems replicable using skill-less macro top-down approaches when tail risk and stale pricing are taken into account.